somewhat pear-shaped, the large end lying ventrally. The lumen is retained until the fusion with the median part is accomplished by the union of the large end of the side components with the central division: the large end soon after assumes the characteristic net-like form of the thyroid gland; but the lateral portions can still be distinguished for some time by the lesser size of the meshes, and the greater size of the cords of the network into which they change.

In the introduction to his article, Born refers to the previous writings of Stieda and Wölfler, and closes with a criticism of the same, and other publications based upon his own researches. The most important point to be noticed is the correction of Wölfler's mistake in describing the second cleft as the first. (In this abstract, the author's arrangement of the matter has not been followed, as it appeared little conducive to clearness). C. S. Minot.

RESEARCHES ON ASTRONOMICAL SPECTRUM-PHOTOGRAPHY.

At the time of his death, in November, 1882, Dr. Henry Draper had, for a number of years, been largely occupied with very tedious and costly investigations connected with the photography of the spectra of the heavenly bodies, his unusual adaptedness for the prosecution of which research conducted him to results of the highest importance. With true scientific spirit, Mrs. Draper has generously placed at the disposal of Professor Young and Professor Pickering all the data necessary for the proper publication of the work; and, in a monograph of about forty pages, the former gives an introduction to Dr. Draper's researches, together with a description of the apparatus with which they were made, extracts from the original note-books, and a list of the photographic plates in Mrs. Draper's possession; while the latter, who took a number of these plates to the observatory of Harvard college in the spring of 1883, presents the results of his measurements, accompanied by a discussion of the plates.

Dr. Draper's attention appears to have been first turned toward spectrum-photography in 1869 and 1870, although his photographic work in other fields previously to this time had been singularly successful. His first work in science, conducted while a medical student in New York, and which related to the function of the spleen, was illustrated with microphotographs of great excellence; and very soon after taking his degree, while on a visit at Parsonstown, Ireland, he became so thoroughly impressed with the photographic possibilities of the great reflecting-telescope of the Earl of Rosse, that, soon after his return home, he began the construction of a metallic speculum of fifteen inches diameter, which was soon replaced by a number of silver-on-glass mirrors of about the same size, the details of the construction and mounting of which formed the subject of one of the Smithsonian contributions to knowledge, published in 1864. Seven years later, he had completed with his own hands the entire construction and mounting of a twenty-eight inch silvered-glass mirror, with which he obtained, in May, 1872, his first photographs of the spectrum of α Lyrae by merely inserting a quartz prism in the path of the rays, just inside the focus of the small mirror, and employing neither slit nor lenses. Three months afterward, the same method secured for him plates showing four lines in the spectrum of the same star. For two or three years following, Dr. Draper's time was, for the most part, occupied with other lines of work, connected with investigations of the solar spectrum, and the superintendence of the photographic preparations for the transit of Venus of 1874. He returned to the subject of stellar spectra in 1876, obtaining a number of photographs with a fine twelve-inch refractor by Alvan Clark & Sons. This instrument, now the lesser telescope of the Lick observatory, was replaced in Dr. Draper's establishment, in 1880, by an eleven-inch Clark refractor, which was provided with a correcting-lens fitted to be placed in front of the object-glass to adapt it to photographic work. This instrument was mounted on the same set of axes with the twenty-eight inch Cassegrain mirror, as were also a finder of five inches aperture, and one of two inches, — all of which are well shown in the picture of the telescopes in the Hastings observatory, vol. i. of *Science*, p. 31.

Dr. Draper's eminent successes in celestial photography were due in large degree to his own skill and discoveries in the manipulation of the sensitized plates. Until 1879, wet collodion plates were used in all his experiments; but after that time he employed exclusively the dry plates made by Wratten & Wainwright, to the admirable performance of which, in the hands of Dr. Huggins, his attention was called by that distinguished astronomical physicist, on a visit of Dr. Draper to England in 1879.

Professor Young directs attention to the fact that the investigations of stellar spectra were by no means carried on continuously, but only during Dr. Draper's summer residence at his country-place, and in the intervals of other, to him, even more absorbingly interesting researches and urgent business occupations. The difficulties proved to be well-nigh insurmountable; for at first the limitations imposed upon the time of exposure by the use of the wet process made it almost impossible to get impressions of sufficient strength, — a difficulty which vanished on the introduction of the modern dry-plate processes: and another difficulty, increasing with the length of the exposure, was that of securing a sufficiently accurate movement of the driving-clock. No less than seven such clocks were constructed before he succeeded in getting a perfect one. Its regulator was a pair of heavy conical pendulums, so hung that their revolutions were sensibly isochronous through quite a range of inclination. The gearing and driving-screw were constructed, for the most part, by Dr. Draper himself, with the utmost care and accuracy; and Professor Young says, that, in its ultimate perfected condition, the driving-clock was as good as any in existence, being able to keep a star upon the slit for an hour at a time, when near the meridian, and not disturbed by changes of refraction.

And besides, the effect of changes of temperature upon the spectroscopic portion of his apparatus, and the difficulty of securing nights on which the atmosphere would not cut off the actinic rays to an unusual degree, not to mention the fact that the observatory was more than two miles distant from his residence, — these and many other conditions hindered the progress of the work. Spectrographic operations are, as Professor Young well says, much more sensitive to atmospheric conditions than are visual observations.

As regards the spectroscopic apparatus, a great many forms were employed, the first of which has already been mentioned. Later, direct-vision prisms were used in the same way, and spectroscopes made up of such prisms, some with a slit, some without, and some with a cylindrical lens to give necessary width to the spectrum. In the definitive arrangement of the apparatus, with which all the plates measured by Professor Pickering were made, a remodelled form of Browning's star-spectroscope formed the basis of the instrument; the telescope and collimator each having a focal length of six inches, and an aperture of 0.75 of an inch. The eye-piece and micrometer being removed, a block of hard wood was fitted on in such a way as to carry the photographic plate (a small piece of glass about an inch square); and a small positive eye-piece was mounted on the block, so that the yellow and red portions of the spectrum, projected beyond the sensitive plate into the field of view, could be examined at pleasure. It was thus possible to be sure that the driving-clock was running properly, and that all the adjustments remained correct. The whole apparatus weighed less than five pounds, and could be screwed on the eye-end of whichever telescope it was desirable to use it with. The development of the plates was usually by ferrous oxalate, though the alkaline development and pyrogallic acid were both used on some occasions. The pictures were about half an inch long, and one-sixteenth of an inch in width, extending from a point between the Fraunhofer lines *F* and *G* to a point near *M*.

Professor Pickering divides his work on these plates into three parts: first, the determination of the relative positions of the lines in the various spectra in terms of any convenient unit of length; second, from the known spectra of the moon and Jupiter, a determination of the relation of these measures to wave-lengths; third, a reduction of the measures of the stellar spectra to wave-lengths, and a discussion of the results. The stars whose spectra have been measured are *α* Aquilae, *α* Lyrae, *α* Aurigae, *α* Boötis, and *α* Scorpii. The spectrum of the first of these stars is remarkable for containing, in addition to the intense broad hydrogen-bands which characterize the spectrum of *α* Lyrae and similar stars, a multitude of very fine lines, which are easily seen between *G* and *H* in several of the plates, but are too delicate to be satisfactorily measured. Dr. Draper considered these fine lines very important as showing that Altair should be regarded as a sort of intermediate link between *α* Lyrae and Sirius on the one side, and Capella and the sun on the other.

On the plates of the spectra of *α* Aurigae and *α* Boötis, not only do the lines appear to coincide in position with those of the sun, but their relative intensity seems to be nearly the same. Of the twelve lines seen in at least seven of the nine spectra of the moon and Jupiter, every one is contained in the spectra of both *α* Aurigae and *α* Boötis. Of the fifteen lines which are so faint as to be contained in but one or two of the spectra of the moon or Jupiter, only four are contained in the spectrum of *α* Boötis, and but one in that of *α* Aurigae. There is therefore no room for doubt of the correctness of Professor Pickering's conclusion that the evidence afforded by these photographs is very strong indication of the sameness of their constitution with that of our sun.

Professor Pickering's method of deriving his results from these plates is worthy of note here, as indicating the great degree of confidence to which they are entitled. To secure entire independence in the results, the measures were completed before the reductions were begun. The lines in each plate were measured without comparison with any map, and no search was made for lines which appeared to be wanting. When two similar spectra were photographed side by side, care was taken to cover one when measuring the other. Under these circumstances, the agreement in the measures of several plates is strong evidence of the identity of the spectra.

Appended to this monograph are three of the papers of Dr. Draper, reprinted from the *American journal of science:* 1°, On photographing the spectra of the stars and planets (December, 1879); 2°, On photographs of the spectrum of the nebula in Orion (May, 1882); and, 3°, Note on photographs of the spectrum of comet *b* 1881 (August, 1881). The first of these papers gives, in brief form, a very lucid statement of the conditions of the problem of celestial spectrum-photography, as well as the obstacles which he had, up to that time, overcome in solving it.

DAVID P. TODD.

THE GEOLOGY OF THE ASTURIAS AND GALICIA.

Recherches sur les terrains anciens des Asturies et de la Galice. Par CHARLES BARROIS, docteur ès-sciences. Lille, *Six-Heremans*, 1882. 630 p., 20 pl. 4°.

IT was the good fortune of one of the writers of this review to see this work in process of evolution in the workshop and study of its hospitable author in Lille; but much as he admired the indomitable energy and patience which were presiding at its birth, as well as the copious notes and experience which were being assimilated into this monograph, the result is a surprise. How much more must it surprise those who are unacquainted with Dr. Barrois, to learn that he is but little past his thirtieth year; that this is but one of several important memoirs which he has begun and